TO PAULINE
Who believes everything I say
AND HAROLD
Who doesn't believe a word.

ULTRASONIC ENGINEERING

WITH PARTICULAR REFERENCE TO HIGH POWER APPLICATIONS

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Curie point, the limiting temperature will be governed by the insulation on the windings. With glass or silicone insulated wire it is possible to operate at temperatures up to about 400° C and the transducer can therefore be used without special cooling facilities with liquids at this temperature, such as zinc, tin and soft solders. The complete transducer can be wholly immersed, but the cavitation erosion is considerable at elevated temperatures and it is therefore desirable to have replaceable active faces on the transducer to avoid permanent damage to the laminations. The presence of erosion pitting causes loss of ultrasonic power and repeated resurfacing will alter the resonant characteristics as well as necessitating further annealing to remove work hardening. Finally, in many cases adulteration of the liquid under treatment may be undesirable and the transducer face can be surfaced with a more suitable metal.

For treatment of higher temperature melts, cooling must be provided for the transducer. To avoid local cooling at the coupling point causing a build-up of solidified metal, the entry face in contact with the liquid under treatment must be at a temperature approaching that of the liquid. Apart from conduction of heat from the melt to the transducer there will also be some radiation from the molten surface. All these factors make it desirable to locate the transducer at some distance from the liquid under treatment.

This can be done by providing an acoustic coupling consisting of a bar of physical dimensions which are functions of the wavelength of the ultrasonic wave being generated. The bar may be made of many types of materials provided that they are homogeneous in structure, are capable of withstanding the mechanical stresses involved, and possess suitable temperature characteristics. The influencing factor, however, is the ease with which they can be mechanically coupled to the transducer face to provide an efficient acoustic joint. The demountable transducers previously mentioned have been tried but with limited success and effective coupling is usually carried out by soft or hard soldering. One advantage of using a coupling bar is that by making the bar of a tapering form with the taper as an exponential function of the length, the amplitude will be increased in inverse proportion to the diameter. A transducer fitted with a stub of this form is shown in *Figure 73* and has provision for water cooling. The high particle velocities achieved by this means have been found to be advantageous for grain refinement in molten metals and for degassing liquids and melts.

For treatment of light metal melts such as aluminium and magnesium a low carbon content mild steel bar has been used with some success, the bar being hard soldered to the transducer face and

the laminations being arranged for water cooling by enclosing them in a jacket. A multiplicity of heads fitted with stubs can be positioned in a mosaic pattern to obtain a large coverage. It has been suggested that if the bar is composed of the metal being treated and the active tip allowed to reach melting temperature, a high efficiency of transfer could be achieved. As the bar will be slowly consumed the change in dimensions will alter the antinodal point and the amplitude will fall. Normally, however, treatment only commences during the cooling cycle of the melt and loss by melting may be quite small.

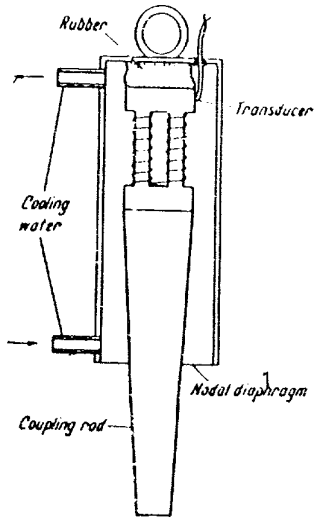

Figure 73. Water-cooled transducer fitted with tapering coupling stub

In any case, for treatment of metals in order to produce structural changes the irradiation must continue until solidification is complete in order to set the crystal pattern or dispersed particles, and whichever method is used there will be the necessity for breaking the stub away from the surface of the melt.

Quartz, silica and graphite rods have also been used as coupling elements and one method of joining these to the transducer face is to use a cement such as Araldite. The transfer efficiency of cemented joints at high powers is moderate and it falls off rapidly in use due to mechanical fatigue at the joint surfaces. Graphite is difficult to obtain with a homogeneous structure although otherwise possessing a number of metallurgical advantages in its use. It has been noted that if quartz or silica is employed the dipped end